SCHOOL OF
CIVIL ENGINEERING

INDIANA
DEPARTMENT OF HIGHWAYS

JOINT HIGHWAY RESEARCH PROJECT

JHRP-89/5 -2

Executive Summary

# AN INVESTIGATION OF SURFACE COATINGS ON EXPOSED CONCRETE

Luh M. Chang

Peter S. Garner


PURDUE UNIVERSITY

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To: H. L. Michael, Director
Joint Highway Research Project

May 3, 1989

From: Luh M. Chang, Research Associate
Joint Highway Research Project

Project: C-36-67BB
File: 9-11-28

Attached are the Executive Summary, Final Report, Technical Summary, and Implementation Report for JHRP Study titled "An Investigation of Surface Coatings on Exposed Concrete." These reports and summaries are authored by Luh Chang and Pete Garner.

The objectives of the Study were accomplished. Many different surface coatings were identified, tested, and evaluated. It appears that concrete coated with the recommended materials can reduce the absorption of moisture and chlorides into the concrete, help the concrete achieve a longer life, and maintain its aesthetic integrity.

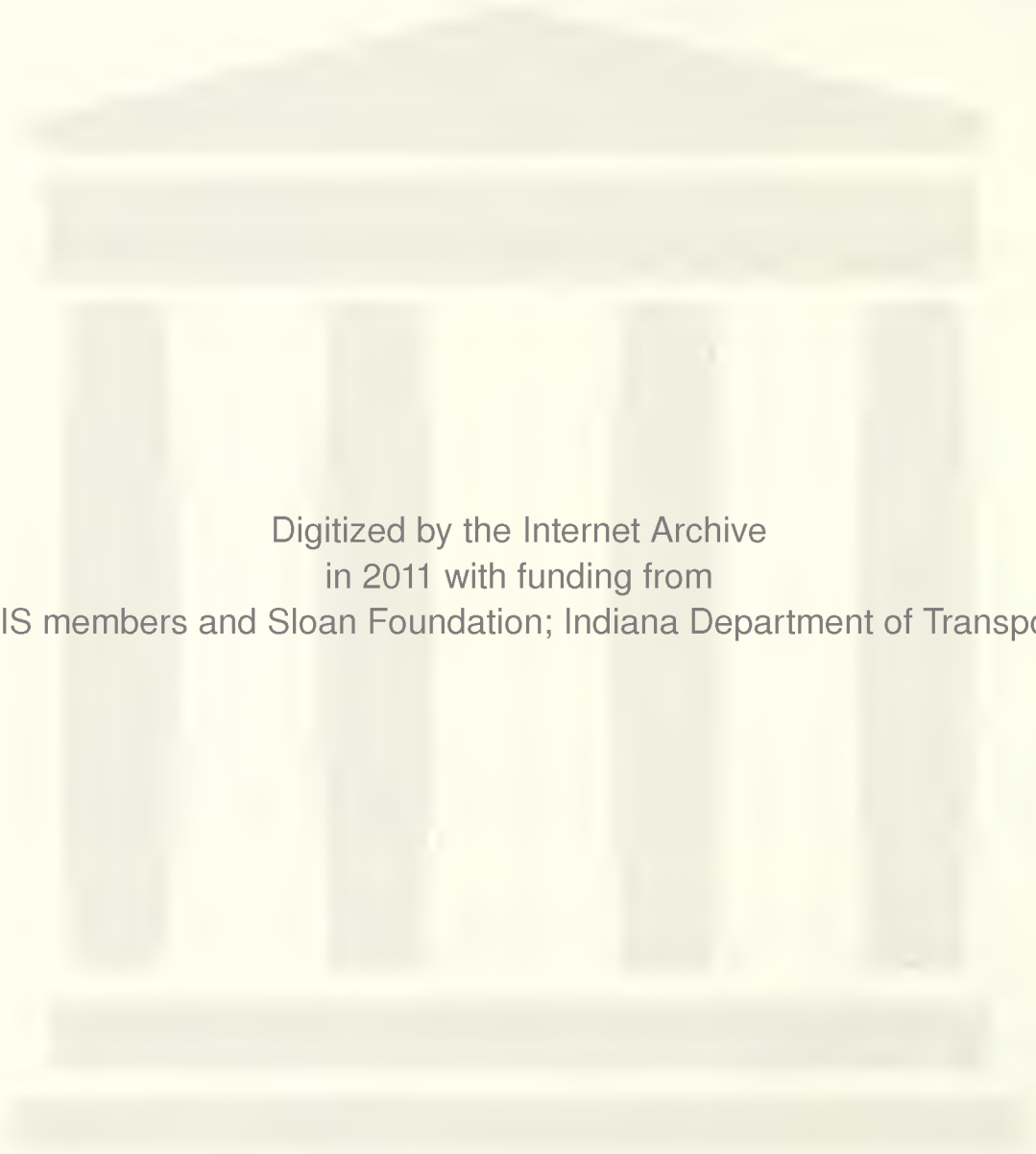
A full set of recommendations and conclusions detailing the results of this project has been included.

I am transmitting this final report as fulfilling the objectives of the study.

Sincerely,

Luh M. Chang
Research Associate

LMC/no



# AN INVESTIGATION OF SURFACE COATINGS ON EXPOSED CONCRETE

by

Luh M. Chang, JHRP Research Engineer, Purdue University
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Joint Highway Research Project
Project No.: C-36-67BB
File No.: 9-11-28

PURDUE UNIVERSITY
School of Civil Engineering
West Lafayette, Indiana

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## EXECUTIVE SUMMARY

Concrete is a highly alkaline material. It is subject to chemical or even pure water attack. The reinforcing steel inside concrete structure could be seriously corroded if the concrete is not sealed and porous to chloride, sulfate, other common ions, and oxygen. Meanwhile, the concrete could be peeled, blistered, or thoroughly disrupted by the unchecked moisture. Especially, the physical forces of ice during freeze and thaw cycle would cause the concrete to spall and shatter. Besides, concrete is a comparatively dull gray material.

Attempts to minimize the aforementioned problems have been made through the application of surface sealers/coatings to the concrete. The use of effective surface sealers, coatings, or penetrants on bridge members or other concrete structures, not only prevents permeation of the chloride ions, chemical attack and absorption of moisture. This also extends the life of the concrete structures, reduce maintenance and rehabilitation costs, and enhance the appearance of the concrete structure.

Although the use of sealers/coatings has met with varying degrees of success, it is not uncommon for the sealers/coatings to result in earlier failure or discoloration of the concrete surface, which degrades the aesthetics of the structure.

In addition, new coating systems are emerging in the market almost every day. Many highway engineers are continually facing the challenge to select a proper coating system for the construction projects in which they are involved. Moreover, the current practice of concrete surface coating in Indiana highway construction seems a somewhat complicated process requiring sandblasting prior to sealing, followed by another sandblasting in preparation for coating.

To deal with these problems, a research is conducted by Purdue University for the Indiana Highway Department.

## Objective of The Research

The objective of this research is to evaluate generic types of sealer/coating systems and ascertain which are suitable for use in highway construction on non-wearing concrete surfaces within the State of Indiana. This was accomplished by studying he effectiveness of different surface sealers/coatings when applied on concrete and subject to different laboratory experiments. The effectiveness was established by determining if these materials could minimize or prevent the intrusion of chloride-concentrated water into the concrete while maintaining structural and esthetic integrity.

## Research Methodology

Since this research was aimed at investigating as many different chemical types of sealers/coatings as possible, the research approach included an extensive literature search of libraries, interviews with personnel of surrounding highway departments, and contacting chemical companies to select the appropriate generic types of coating systems for testing. Three different laboratory experiments were undertaken on the selected materials. Thus, the research consisted of the following tasks:

Task 1 - Identify the present state of the art of sealers/ coatings that are available on the market and that are used successfully in the surrounding states by means of an extensive search.

Task 2 - Determine the ability of these sealers/coatings to resist water and chloride ion absorption and vapor transmission.

Task 3- Determine the ability of these sealers/coatings to resist chloride ion penetration in a chloride ion permeability test.

Task 4 - Determine the resistance of these sealer/coatings to accelerated weathering in terms of ultra-violet radiation, heat, and freeze/thaw cycles.

Task 5 - Recommend proper procedures for application of these sealers/coatings and means of laboratory evaluation.

## Results and Conclusions

After a thorough extensive search, interviews with experts, and contacts with many state highway agencies, 25 out of 120 identified coating systems were selected, tested, and compared to the uncoated control specimen.

Although significant variations exist among these numerous coating systems subject to various testings, there are certain chemical formulation of coating systems that exhibit comparatively better performance. The results can be summarized as follows:

1. All of the materials performed better than the untreated control specimen. This conclusion held true for all but a few of the test results.

2. The epoxies were effective chloride and water absorption barriers, but did deteriorate and discolor slightly in the accelerated weathering test.

3. The penetrants (straight silanes, silicone, and siloxane) were relatively good in terms of their ability to resist water and chloride absorption. The also showed very little signs of deterioration in the weathering test. The materials that were combinations of the above penetrants did not perform as well as the straight penetrants.

4. The urethanes and methyl methacrylates did not perform consistently across all three tests. Their results varied dramatically from one test to another.

5. Masonry coatings were quite ineffective chloride barriers, but they do have esthetic qualities. This statement was confirmed across each of the different experiments.

6. The materials with the higher solids content or active ingredients performed better in all of the tests. This was found to be true for the epoxies, silanes, and urethanes.

7. The rapid chloride permeability testing method is a quick test method. However, the results obtained from this test method were not consistent with the other tests conducted in this research.

8. It was found that the longer the curing period, the increased percent reduction of chloride permeability compared to the control.

## Recommendations and Future Study

1. In spite of the fact that significant variations in performance existed among these 25 coatings, five specific formulations of different coating systems consistently demonstrated a comparatively distinguished performance from the others and a significant improvement from the non-coated control specimen.

The five coating systems are: No. 1 - Epoxy (50% solid), N0. 2 - Silane (40% active ingredients), No. 11 - Silicone (5% solid), No. 14 Siloxane (10% solids), No. 25 - Epoxy ( 100% solid). We recommend these five coatings to be added to the IDOH List of Approved Proprietary Portland Cement Concrete Sealers.

2. This study concluded that the epoxies were effective chloride and water absorption barriers, but deteriorate and discolor slightly in the accelerated weathering test. In contrast, masonry coatings were quite ineffective chloride barriers, but could preserve the coated color and hold concrete surface almost intact after long and severe accelerating weathering test. If aesthetics is a desired feature of the coating system,we recommend that a masonry system be applied over epoxies or other good sealers which have proved quality in stopping chloride, moisture, or chemicals penetration.

3. As mentioned previously, we recommend two preliminary tests be run on materials to be evaluated - the water absorption/vapor transmission/chloride titration test and the chloride ion permeability test. The accelerated weathering test could then be run on the certain materials that performed well in the preliminary test for final approval or disapproval.

4. The experimental results confirmed and verified the minimum requirement of 3-days dry cure prior to the application of epoxy penetration sealers in the Standard Specification of Indiana Department of Highway (709..04-b-environmental requirements for epoxy penetrating sealers). Therefor, it is recommended that a minimum of 3-days dry cure after 4 days wet cure be needed before applying the epoxies on the concrete surface.

5. There was no statistically significant difference on subjecting three different cure periods (at 9,19, and 28 days age) for four different types of Alkyle-Alkoxy Silanes in Water Absorption/vapor Transmission Test of this study. A further study is recommended to determine a shorter cure period. Thus, a shorter construction time may be achieved.

6. Sandblasting newly placed concrete before adequate cure will excessively remove the very fine layer of paste on the new fresh concrete surface . The layer of paste retains moisture inside the concrete for hydration with cement. The removal of the layer causes the concrete upper surface to dry faster and leaves unhydrated cement inside the concrete. The unhydrated cement will later react with the water, change the microstructure of concrete, and create new concrete surface which weakens the bond between the sealer and concrete.

It is recommended that sandblasting be done immediately prior to application of coating/sealer. The longer the concrete is cured, the harder the paste layer of concrete will be, the less paste will be sandblasted out, and the better the fine layer of paste and concrete cure will be. This procedure will not only avoid arbitrary judgement but will also save the time and cost of resandblasting.

7. In future research, it is recommended that the effects of ultraviolet radiation be determined on concrete with a surface coating/sealer applied on them. The U.V. source should be located as close as possible to the concrete in order to simulate as many exposure-days as feasible. The effects of the U.V. could be measured with a glossmeter color measuring, and/or brightness measuring instruments. The U.V. wavelengths that are particularly damaging to the coating/sealers should be determined. Also, some of the better quality coatings/sealers could be applied to concrete pavement to increase the life of the road. Tests would have to be run to determine the wear or abrasion resistance of the applied materials.

COVER DESIGN BY ALDO GIORGINI